

EFFECT OF DRIP IRRIGATION AND BICOLOUR POLYETHYLENE MULCH ON GROWTH, YIELD AND WATER PRODUCTIVITY OF COLE CROPS IN EASTERN HILL PLATEAU REGION OF INDIA

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ABSTRACT

The study was undertaken to evaluate the efficacy of drip irrigation (DI), drip irrigation with bicolor polythene mulch (DIM) and furrow irrigation (FI) for the cultivation of cabbage, cauliflower and broccoli in Ranchi, Jharkhand. The irrigation treatments were replicated thrice in a factorial randomized block design. Compared to FI, the plant height, curd initiation, curd weight and yield increased significantly under DIM and DI. The DIM resulted in significantly highest curd yields of 31.25 t ha⁻¹, 26.34 t ha⁻¹ and 10.13 t ha⁻¹ for cabbage, cauliflower and broccoli, respectively while the lowest yields of 23.91 t ha⁻¹, 14.56 t ha⁻¹ and 5.49 t ha⁻¹, respectively were recorded under FI. The highest water use efficiency (14.83 kg m⁻³) of cabbage was obtained under DIM and lowest in FI (4.90 kg m⁻³). Similarly, in cauliflower DIM recorded the highest water use efficiency of 12.61 kg m⁻³ and lowest in FI (7.44 kg m⁻³). The broccoli recorded the highest water use efficiency under DIM (4.729 kg m⁻³) and lowest in FI (1.39 kg m⁻³). The DIM also recorded the highest economic water productivity for cabbage (147.28 Rs m⁻³), cauliflower (124.66 Rs m⁻³) and broccoli (97.15 Rs m⁻³) followed by DI. The lowest economic water productivity was recorded under surface irrigated cabbage (25.63 Rs m⁻³), cauliflower (16.86 Rs m⁻³) and broccoli (15.90 Rs m⁻³). DIM registered highest available N and K content in the post-harvest soil of winter crops and resulted in 9 and 14.3 % increase over conventional surface irrigation. Further, the uptake of N, P and K was more in cabbage followed by cauliflower and broccoli. The yields of cabbage, cauliflower and broccoli obtained under DIM were 6.98, 32.30, 31.56 % higher yields over DI and 30.70, 80.91, 84.52 % higher over furrow method of water application. Thus the drip system in conjunction with polyethylene bicolor silver black mulch technology is very effective for commercial cultivation of cabbage, cauliflower and broccoli in the eastern hill plateau region of India.

KEY WORDS: Furrow Irrigation, Drip Irrigation, Bicolor Polythene Mulch, Fertigation, Water use Efficiency & Economic Water Productivity

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INTRODUCTION

The water scarcity and rising water costs, there is tremendous scope for increasing the use of drip system in India. The share of water for agriculture is expected to reduce from the present level of 85% to 69% by 2025. In contrast, the water demand for agricultural purposes is estimated to increase in order to produce more horticultural produce and raw material for large population & expanding food industry. The actual agricultural water demand is estimated to increase from 470 Billion Cubic Meters (BCM) in 1985 to 740 BCM in 2025. China and India are the largest producers of cauliflower and about 70% of the world cauliflower production occurs in Asia (FAO Stat,

2012). Jharkhand is the sixth major cauliflower producing a state in the country. It produces about 0.36 MT *i.e.*, 6 % of total production of cauliflower in the country with a national production of 4.694 m MT per year. The area coverage under cauliflower in Jharkhand is 0.02 m ha against coverage of 0.256 m ha in the country. The average productivity of cauliflower in the county is 18.3 m t ha⁻¹ and in Jharkhand state is 16 t ha⁻¹ in the year 2012 (NHM Report, 2012). India ranks second after China in broccoli production, cultivation in an area of 0.1 M ha, having production 6.74 of MT (Cabbage and cauliflower). The productivity of Broccoli in China is 49.8 t/ha, whereas in India only 18.3 t/ha (FAOSTAT-2015). India ranks second in area and production, fifth in productivity globally in Broccoli.

The vegetables under drip irrigation and drip irrigation with mulch play an important role in efficient utilization of water and nutrients as well as crop yields & quality produce. Mulching is one of the simplest and most beneficial practices that can be used in the cultivation of vegetables in conjunction with drip irrigation. The plastic mulch has numerous benefits as it protects the soil from erosion, reduces compaction from the impact of heavy rains, conserves moisture, reduces the need of frequent watering, maintains a more even soil temperature, prevents weed growth, improves the condition of the soil and minimizes the labour cost. These plastic mulches are easier to spread on the soil surface and, available at cheaper rates and widely available in the market and may last for one to three seasons or more depending on their thickness. However, the use of plastic mulches of dual colour *i.e.*, black silver mulch in vegetable crops is to be studied in the eastern plateau hill region. Traditionally, furrow irrigation for vegetable cultivation is being followed by the farmers from several years and efficient utilization of water and nutrients are not being utilized. The drip irrigation and drip irrigation with mulches for vegetables to be compared with furrow method of irrigation which is not an optimum practice for efficient utilization water and nutrients.

MATERIALS AND METHODS

The experiment was conducted consecutively for three years during 2015-16, 2016-17 and 2017-18 during rabi season at research farm of ICAR-RCER, Research Centre, Ranchi, Jharkhand, India (23°16' N latitude and 50° 85' E longitude and 629 m AMSL altitude with average annual rainfall of about 1350 mm and annual evaporation of about 1962.7 mm). The three irrigation comprises of drip irrigation (DI), drip irrigation with bicolor polythene mulch (DIM) and furrow irrigation (FI) for the cultivation of cabbage, cauliflower and broccoli were laid out in Randomized block design with three replication. The initial soil status of experimental plots showed soil reaction of 4.65pH, 0.30 EC (mS/cm), available nitrogen (147 Kg/ha), available potassium (200 Kg/ha) and available phosphorus were found below detection level. The cauliflower, cabbage and broccoli seedlings were transplanted as rectangular crop geometry with two rows per lateral system at 40 cm plant to plant & 60 cm row to row. The same dose of fertilizer and fertigation schedule were applied for all the three crops. The recommended dose of 150:60:60 Kg/ha NPK was applied. In the conventional system of irrigation, two third of basal dose of N & full dose of P & K was applied and one-third of N was applied as a top dressing after 45 days after transplanting.

Growth and Yield Attributes

The plant height of Cauliflower, Cabbage & Broccoli was taken at 20, 40, 60 days after transplanting in FI, DI & DIM. The DIM irrespective of crops showed significantly higher plant height in companion to DI & SI. The similar results were obtained by Ashrafuzzaman *et al.*, 2011 that increase in plant height in mulched plants was possibly due to better availability of soil moisture and optimum soil temperature provided by the mulches. The number of leaves occurrence was also taken at 20, 40, 60 days after transplanting. It was recorded that the system of irrigation & mulching has not significant on the occurrence of leaves in cabbage, cauliflower & broccoli. The weed biomass in different treatments of FI, DI & DIM was recorded. It was found that the FI recorded maximum weed biomass in comparison to DI and DIM. The DIM recorded maximum weed biomass irrespective of crops. The curd initiation was also recorded among the different crops and methods of irrigation and mulched one. The curd initiation was found the maximum in DIM followed by DI and least in FI. The cauliflower and cabbage showed the higher response of mulch in curd initiation in comparison to broccoli.

The yield of the plant was significantly affected by methods of irrigation & mulch. The DIM recorded highest yield in cabbage (1.30 kg plant⁻¹), Cauliflower (1.13 kg plant⁻¹) & broccoli (0.47 kg plant⁻¹). Similar findings were also reported by Jha *et al.*, 2018 that mulched treatments recorded higher curd yield plant⁻¹ in cauliflower and a highest average weight of curd plant⁻¹ for consecutive four years in comparison to without mulched treatments. The cauliflower, cabbage and broccoli yield were significantly affected by the method of irrigation and mulch over furrow irrigation as depicted in Table 1. The DIM recorded highest yield of cabbage pooled mean (31.25 t ha⁻¹), cauliflower (26.34 t ha⁻¹), and broccoli (10.13 t ha⁻¹) followed by DI cabbage 29.01 t ha⁻¹, Cauliflower 19.91 t ha⁻¹ and broccoli 7.70 t ha⁻¹ and least in FI (cabbage 23.91 t ha⁻¹, Cauliflower 14.56 t ha⁻¹, broccoli 5.49 t ha⁻¹) respectively. The result was found in conformity with Mishra *et al.*, 2008 who reported that the drip irrigation requirement through drip with black LDPE mulch and yield of cashew was found to be 109 % higher than basin irrigation. The high yield in drip irrigation with mulch provides a better growing environment to the crop. This result was found in conformity with Ashrafuzzaman *et al.*, 2011 that the mulch had a positive effect and produced the highest fruit weight per plant and per ha in chili. Similar reports have been reported by Kumari (2012) that black polythene mulch plus drip irrigation conserved soil moisture, stimulated shoot growth, and produced higher leaf area and yield in potato. The result obtained is also in agreement with the findings of Tiwary *et al.*, 1998. The reasons of low yield in basin irrigated crops may be due to the crop has to undergo water stress during last few days before next irrigation, especially at the critical period, coupled with aeration problem last few days immediately after irrigation. Moreover, due to the heavy application of irrigated water the nutrients may have got leached down the root zone of the crops, further the reason may be attributed to high weed infestation between the crops. This result corroborated with findings of Subramanian *et al.*, 1997 and Patnaik *et al.*, 2003.

Table 1: Yield Attributes of Cole Crops under Different Methods of Irrigation (t/ha)

Treatment	Cabbage			Pooled Mean	Cauliflower			Pooled Mean	Broccoli			Pooled Mean
	2016	2017	2018		2016	2017	2018		2016	2017	2018	
Furrow Irrigation (FI)	27.26	22.99	21.47	23.91	12.61	15.86	15.20	14.56	5.21	4.05	7.21	5.49
Drip Irrigation (DI)	30.65	29.45	27.51	29.21	19.89	19.14	20.69	19.91	6.63	5.57	10.90	7.70
Drip Irrigation +Mulch (DIM)	31.90	30.67	31.17	31.25	26.62	25.33	27.07	26.34	10.27	7.09	13.01	10.13
Cd (5%)	2.58	2.30	2.52		2.58	2.30	2.52		2.58	2.30	2.52	

The percentage increase of yield over methods of irrigation recorded maximum in cauliflower and broccoli in comparison to cabbage. The yields of cabbage, cauliflower and broccoli obtained under DIM were 6.98, 32.30, 31.56 % higher yields over DI and 30.70, 80.91, 84.52 % higher over furrow method of water application. The cauliflower showed highest curd initiation 111.1% & 57.73 % in DIM & DI in comparison to FI, whereas broccoli showed 97.12% & 27.25% curd initiation respectively (Fig.1). The result was also found in conformity with Jha *et al.*, 2017 who reported that adoption of drip irrigation improved the yields in the range of 38.2 to 65.8 % over furrow irrigation with highest yield increase in case of pea (65.8%) and tomato (58.7%). The cabbage showed the least affect on curd initiation of 17.02% & 11.06% over FI. The lowest yield in non mulched treatments might be because of unfavourable moisture regime (moisture stress) in the soil and competition of weeds for nutrients (Pattanaik *et al.*, 2003). The higher yield in mulched treatment was attributed to the maximum number of leaves of plants grown on broad beds and ridge and furrow, which might have increased photosynthesis and availability of carbohydrates for cauliflower growth and curd development.

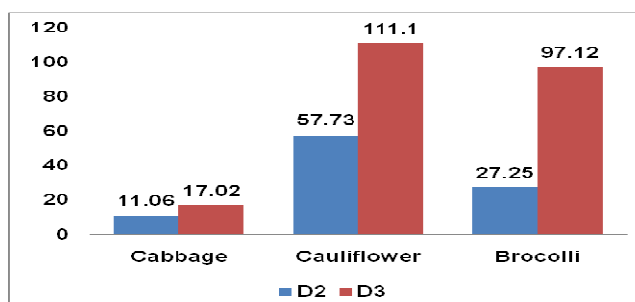


Figure 1: Percentage (%) Increase of Curd Initiation under Methods of Irrigation

Water Use Efficiency & Productivity

The water use efficiency (WUE) under different treatments in cabbage, cauliflower & broccoli indicated a significant difference among the irrigation methods are depicted in Table 2. The highest WUE (14.83 Kg m⁻³) was recorded in DIM in cabbage followed by DI (13.88 Kg. m⁻³) & least in FI (4.90 Kg m⁻³). Similarly in cauliflower the DIM recorded maximum water use efficiency (12.61 Kg m⁻³) followed by DI (10.43 Kg. m⁻³) and least FI (7.44 Kg m⁻³). In broccoli the highest water use efficiency of 10.13 kg m⁻³ was recorded in DIM followed by DI 7.70 kg m⁻³ and least in FI (5.49 kg m⁻³). These results are in conformity with the findings of Lin *et al.*, 2015 that mulching is one of the good

management practices to improve water use efficiency. Lie *et al.*, 2001 also reported that both the grain yield and water use efficiency are increased by mulching.

Table 2: Water Use Efficiency of Cole Crops under Different Methods of Irrigation (kg/m³):

Treatment	Cabbage			Pooled Mean	Cauliflower			Pooled Mean	Broccoli			Pooled Mean
	2016	2017	2018		2016	2017	2018		2016	2017	2018	
Furrow Irrigation (FI)	2.76	2.33	9.6	4.90	8.89	6.61	6.80	7.44	0.53	0.41	3.22	1.39
Drip Irrigation (DI)	13.76	15.58	12.30	13.88	11.9	10.13	9.25	10.43	2.96	2.95	4.87	3.60
Drip Irrigation +Mulch (DIM)	14.3	16.23	13.94	14.83	12.33	13.40	12.10	12.61	4.59	3.75	5.82	4.72
Cd (5%)	3.4	0.86	0.29		3.4	0.86	0.29		3.4	0.86	0.29	

The economic water productivity (EWP) under different treatments in cabbage, cauliflower & broccoli as depicted in Table 3 indicated significant difference among the irrigation methods the highest WP (147.28 Rs m⁻³) was recorded in DIM in cabbage followed by DI (136.53 Rs. m⁻³) & least in FI (25.63 Rs m⁻³). Similarly in cauliflower the DIM recorded maximum water productivity (124.66 Rs m⁻³) followed by DI (94.22 Rs m⁻³) and least FI (16.86 Rs m⁻³). In broccoli the highest water productivity of 97.15 Rs m⁻³ was recorded in DIM followed by DI 73.49 Rs. m⁻³ and least in FI (15.90 Rs m⁻³). A similar report has also been reported by Jha *et al.*, 2017 that the average WP was higher under drip irrigation as compared to furrow method of irrigation.

Table 3: Water Productivity of the Cole Crops under Different Methods of Irrigation (Rs/m³)

Treatment	Cabbage			Pooled Mean	Cauliflower			Pooled Mean	Broccoli			Pooled Mean
	2016	2017	2018		2016	2017	2018		2016	2017	2018	
Furrow Irrigation (FI)	27.6	23.3	25.98	25.63	16.55	16.10	17.93	16.86	10.55	8.2	12.1	15.90
Drip Irrigation (DI)	137.0	155.8	116.8	136.53	88.91	101.3	92.46	94.22	59.29	59.0	102.2	73.49
Drip Irrigation +Mulch (DIM)	143.0	162.3	136.53	147.28	119.0	134.0	120.97	124.66	91.86	75.0	124.6	97.15
Cd (5%)	3.4	9.3	31.8		3.4	9.3	31.8		3.4	9.3	31.8	

Soil Moisture Paradigm

The soil moisture on irrigation and after irrigation days in cabbage, cauliflower and broccoli at 0-20 cm & 20-45 cm are depicted in Figure.2. The soil moisture at 0-20 cm in FI remains high in comparison to DI & DIM whereas in 20-45 cm, moisture remains maximum in DIM. After 4 days of irrigation cabbage, cauliflower and broccoli showed higher soil moisture in DIM followed by DI and least in FI. The soil moisture after 4 days of irrigation at 20-45 cm depth recorded also higher soil moisture in DIM followed by DI & least in FI. Wang *et al.*, (1998) also reported that all type of polythene mulch increased the soil moisture content in chili field compared to control. The soil NPK status in drip with mulch was significantly better than other irrigation methods and cabbage showed highest nutrient uptake than cauliflower and broccoli.

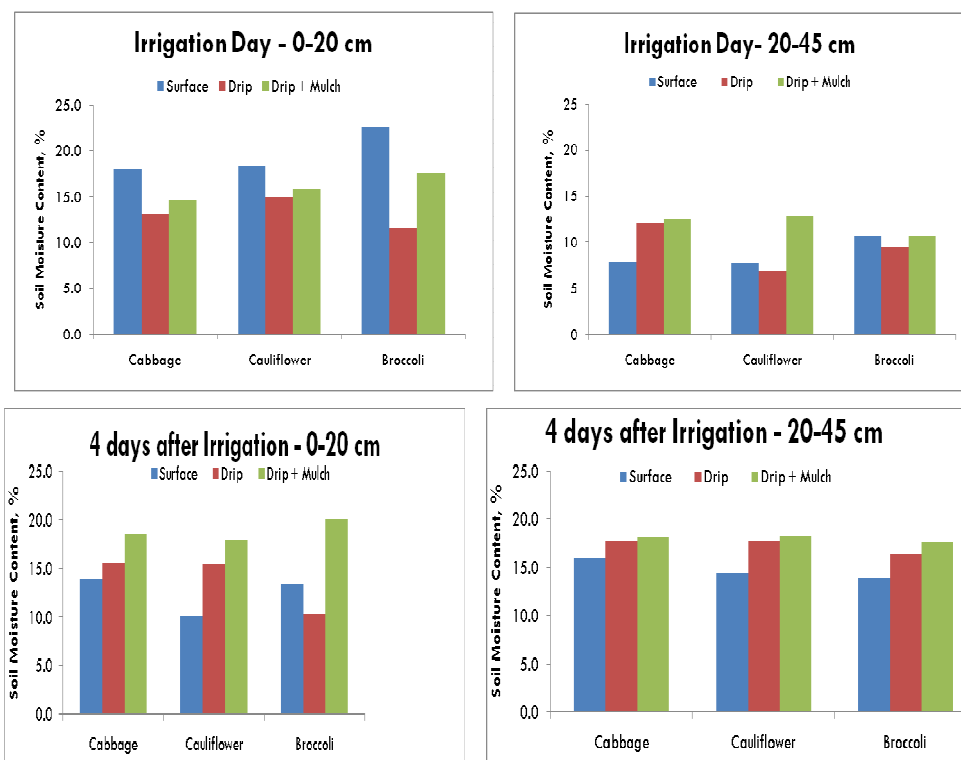


Figure 2: Soil Moisture Variation in Cole Crops under Different Irrigation Methods and Mulch

CONCLUSIONS

The drip irrigation with mulch shows the highest growth and yield attributes, early curd initiation and maturity in cabbage, cauliflower and broccoli than drip irrigation and furrow irrigation methods. It also showed the highest water use efficiency & economic water productivity for all three Cole crops. The soil NPK statuses in drip with mulch was significantly better than other irrigation methods. The cabbage showed highest nutrient uptake than cauliflower and broccoli.

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